Social Differences in Swedish Infant Mortality by Cause of Death, 1983 to 1986

ABSTRACT

Objective. We sought to investigate social differences in Swedish infant mortality by cause of death.

Methods. All live single births in Sweden between 1983 and 1986 to mothers 15 to 44 years old with Nordic citizenship were studied. The causes of death were classified into six major groups. Mother's education was used as a social indicator. Logistic regression analysis was used with identical models for all groups of causes of death.

Results. There were 355 601 births and 2012 infant deaths. Only for sudden infant death syndrome were significant social differences found, with crude odds ratios of 2.6 for mothers with less than 10 years of education and of 1.9 for mothers with 10 to 11 years, compared with 1.0 for mothers with 15 years or more. After adjusting for age, parity, and smoking habits, these ratios were no longer significant.

Conclusions. The social differences obtained could be explained by the fact that mothers with less education smoke more, are younger, and have higher parity than those with more education. (*Am J Public Health.* 1993;83:26–30)

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Introduction

Infant mortality rates have been used to measure the general health and wealth of societies. Early studies pointed to the existence of a social gradient of infant mortality—increasing mortality rates with decreasing social class—and suggested that such differences in mortality would disappear if the population achieved better housing, clothing, and nutrition. Postneonatal mortality in particular has been thought to be affected by improved environmental conditions.[1] During this century, many countries have developed and have been able to provide their population with better and more equitable environmental conditions. In these countries, infant mortality rates, especially those for postneonatal mortality, have decreased.[1,2]

Developments in technology and medicine have led to the survival of many more low-birthweight infants and, in many cases, to the postponement of deaths from the late fetal to the neonatal period and from the neonatal to the postneonatal period. Thus, the relative contribution of neonatal and postneonatal mortality to infant mortality has changed over time and differs between societies.[3] In Sweden, infant mortality is relatively low, and less than 40% of infant deaths occur in the postneonatal period.[4,5] When infant mortality decreases, deaths from some causes are more affected than others and the relative contribution of each cause changes. A study on social differences in total infant mortality is thus influenced by how causes of death are distributed in the study population. For example, infant deaths caused by congenital conditions have slight—if any—association with social class. This cause is responsible for more than one third of all postneonatal deaths among normal-weight infants in Sweden

today.[2] On the other hand, sudden infant death syndrome has repeatedly been shown to be associated with social class.[6,7] The proportion of infant deaths attributable to this syndrome is relatively low in Sweden.[8]

Infant mortality varies with other characteristics as well, such as maternal age, parity,[1,2] and smoking habits.[9] For a better understanding of how the social gradient in infant mortality works, it is important to adjust the class-specific risks obtained for the influence of such possible confounders. The aim of this study is to investigate social differences in infant mortality in Sweden by cause of death, adjusting for the effects of maternal characteristics.

Study Population

This study was based on live births in Sweden between 1983 and 1986, and it was restricted to single births to mothers aged 15 to 44 who were citizens of one of the Nordic countries. Of 382 081 live births, 7673 were multiple births, 5 were of unknown birth type, 341 were to mothers outside the age interval, and 18 461 were to non-Nordic mothers. The remaining total of 355 601 live births constitute the study population.

Data were obtained from four different registers kept by Statistics Sweden

and the National Board of Health and Welfare. Record linkage was possible through use of the mother's and child's personal identification numbers.

From the Birth Register, with information on practically all hospital deliveries covering more than 99% of all births in Sweden,[10] information on mother's identification number, age at delivery, parity, smoking habits, and date of infant's birth was collected. Smoking habits information was based on the mother's self-report in early pregnancy at her first visit to prenatal care.

The Education Register provided information on the length of the mother's formal education as of the end of 1987. Years of education were grouped so as to parallel the Swedish school system, in which a student normally attends comprehensive school for 9 years, spends another 2 or 3 years in secondary school, and takes at least 3 more years to finish undergraduate studies at a university.

The Register of Causes of Death provided information regarding time and cause of infant death using the infant's identification number, which was obtained from the Register of the Total Population. In Sweden, the *International Classification of Diseases*, 8th version (*ICD*-8) was used to classify causes of death through 1986; thereafter the *ICD*-9 was used. The causes of death were classified into six groups according to a classification developed by an international collaborative effort for international comparisons.[11] The groups are congenital conditions, sudden infant death syndrome, asphyxia-related conditions, immaturity-related conditions, infections, and remaining causes (Appendix 1). Between 1983 and 1985, autopsies were performed on 98% of sudden infant death syndrome deaths and on 70% of deaths from other causes.[8]

Statistical Analysis

Mortality rates were calculated for all infant deaths and for each cause of death by comparing all children dying from a certain cause with all live births.

Multiple logistic regression analysis was used to estimate the effects of the independent variables on mortality from a certain cause of death.[12,13] Maternal age, parity, smoking habits, and mother's education were used as independent variables because these have been shown to be important risk factors.[9] All variables were categorized, and each category was treated as binomial. To have the same model for all causes of death, no interaction terms were included and the same reference group (25 to 29 years old, parity 2, and nonsmoker) was used in all analyses. When a specific cause of death was being analyzed, all children who survived the first year were used as controls.

The estimates were used to calculate odds ratios with 95% confidence intervals. As a measure of the model's goodness-of-fit, the likelihood ratio test was used. If the model was not significant at the 5% significance level, the multiple logistic regression model was not considered to be a good description of the mortality of the children dying from that specific cause. In these cases, no confidence intervals are presented.

The analyses were performed with the SAS program package.[14,15]

Results

Among the 355 601 live singleton births were 2012 infant deaths, giving a mortality rate of 5.7 per thousand. Congenital conditions were the main cause,

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TABLE 1—Number of Live Births[a] and Cause-Specific Mortality Rates, by Maternal Characteristics

	Number of Births	Mortality rate per 1000						
		Congenital	SIDS[b]	Asphyxia	Immaturity	Infections	Remaining	Total
Age, y								
15–19	11 566	1.9	1.9	1.0	2.0	0.9	0.3	8.0
20–24	84 203	2.1	1.0	0.5	1.3	0.5	0.3	5.6
25–29	131 785	1.9	1.0	0.5	1.0	0.4	0.5	5.1
30–34	87 795	2.6	0.8	0.6	1.1	0.5	0.3	5.9
35–39	34 640	2.7	0.5	0.8	1.3	0.4	0.4	6.1
40–44	5 612	3.7	0.7	1.2	2.0	0.7	0.5	8.9
Parity								
1	145 447	2.1	0.6	0.7	1.4	0.4	0.3	5.5
2	127 785	2.2	1.1	0.5	1.0	0.5	0.3	5.5
3	59 872	2.1	0.9	0.5	1.0	0.3	0.4	5.3
≥ 4	22 497	2.9	1.9	0.8	1.8	0.7	0.3	8.4
Smoking habits								
Nonsmoker	229 495	2.1	0.7	0.5	1.0	0.4	0.3	5.0
1–9 cigarettes/day	62 457	2.2	1.2	0.6	1.2	0.6	0.3	6.2
≥ 10 cigarettes/day	40 134	2.2	1.9	0.7	1.4	0.4	0.4	7.1
Information not available	23 515	2.9	0.7	1.0	2.6	0.7	0.3	8.3
Education, y								
≤ 9	82 816	2.2	1.4	0.6	1.3	0.6	0.3	6.4
10–11	136 160	2.2	0.9	0.7	1.1	0.4	0.3	5.6
12	29 007	1.8	0.7	0.4	1.1	0.4	0.3	4.6
13–14	50 132	2.0	0.6	0.5	1.1	0.4	0.1	4.7
≥ 15	36 923	2.5	0.5	0.7	1.1	0.4	0.2	5.3
Information not available	20 563	2.5	1.1	0.8	1.9	0.3	1.0	7.6
Total	355 601	2.2	0.9	0.6	1.2	0.4	0.3	5.7
Information on education and/or smoking habits missing	42 472	2.8	0.9	0.9	2.1	0.5	0.5	7.9

[a]Live single births in Sweden, 1983 to 1986, among Nordic citizens.
[b]SIDS = sudden infant death syndrome.

TABLE 2—Odds Ratios by Cause of Death and Length of Mother's Education,[a] with 95% Confidence Intervals if the Model is Significant

Cause of Death/Length of Mother's Education	Odds Ratios (95% Confidence Intervals)		
		Adjusted for	
	Crude	Age and Parity	Age, Parity, and Smoking
Congenital conditions, 778 deaths			
≤ 9 y	1.3	1.3 (0.9, 1.8)	1.3 (0.9, 1.8)
10–11 y	1.3	1.3 (1.0, 1.8)	1.3 (1.0, 1.8)
12 y (reference)	1.0	1.0	1.0
13–14 y	1.1	1.1 (0.8, 1.5)	1.1 (0.8, 1.5)
≥ 15 y	1.4	1.3 (0.9, 1.8)	1.3 (0.9, 1.8)
P of the model	0.2648	0.0012	0.0006
Sudden infant death syndrome, 324 deaths			
≤ 9 y	2.6 (1.6, 4.2)	1.6 (1.0, 2.7)	1.3 (0.8, 2.2)
10–11 y	1.9 (1.0, 2.5)	1.2 (0.7, 1.9)	1.0 (0.6, 1.7)
12 y	1.2 (0.6, 2.3)	1.0 (0.5, 1.9)	1.0 (0.5, 1.9)
13–14 y	1.2 (0.7, 2.1)	1.0 (0.6, 1.8)	1.0 (0.6, 1.8)
≥ 15 y (reference)	1.0	1.0	1.0
P of the model	0.0001	0.0001	0.0001
Asphyxia-related conditions, 214 deaths			
≤ 9 y	1.6	1.7	1.6 (0.8, 3.1)
10–11 y	1.7	1.8	1.8 (1.0, 3.5)
12 y (reference)	1.0	1.0	1.0
13–14 y	1.2	1.2	1.2 (0.6, 2.5)
≥ 15 y	1.7	1.5	1.5 (0.8, 3.2)
P of the model	0.2620	0.1133	0.0447
Immaturity-related conditions, 427 deaths			
≤ 9 y	1.2	1.1 (0.8, 1.7)	1.1 (0.7, 1.6)
10–11 y	1.0	1.1 (0.7, 1.5)	1.0 (0.7, 1.5)
12 y	1.0	1.0 (0.7, 1.7)	1.0 (0.6, 1.7)
13–14 y	1.1	1.1 (0.7, 1.6)	1.1 (0.7, 1.6)
≥ 15 y (reference)	1.0	1.0	1.0
P of the model	0.8747	0.0297	0.0001
Infections, 157 deaths			
≤ 9 y	1.7	1.6	1.5
10–11 y	1.1	1.1	1.0
12 y	1.3	1.2	1.2
13–14 y (reference)	1.0	1.0	1.0
≥ 15 y	1.1	1.0	1.0
P of the model	0.1422	0.1801	0.0942
Remaining causes, 112 deaths (including 12 deaths with causes missing)			
≤ 9 y	2.3	2.5	2.4
10–11 y	2.9	3.2	3.1
12 y	2.3	2.4	2.3
13–14 y (reference)	1.0	1.0	1.0
≥ 15 y	1.6	1.4	1.4
P of the model	0.0624	0.0558	0.1120
Total, 2012 deaths			
≤ 9 y	1.4 (1.1, 1.7)	1.3 (1.1, 1.6)	1.2 (1.0, 1.5)
10–11 y	1.2 (1.0, 1.5)	1.2 (1.0, 1.5)	1.2 (1.0, 1.4)
12 y (reference)	1.0	1.0	1.0
13–14 y	1.0 (0.8, 1.3)	1.0 (0.8, 1.2)	1.0 (0.8, 1.4)
≥ 15 y	1.1 (0.9, 1.4)	1.1 (0.9, 1.4)	1.1 (0.9, 1.4)
P of the model	0.0002	0.0001	0.0001

[a]Based on live single births in Sweden, 1983 to 1986, among Nordic citizens.

reported for 778 deaths (39%). Immaturity-related conditions and sudden infant death syndrome accounted for 427 (21%) and 324 (16%) deaths, respectively. Asphyxia-related conditions caused 214 deaths (11%), and 157 deaths (8%) were caused by infections. Cause of death was missing for 12 deaths; these were grouped with all remaining causes, forming a group of 112 deaths (6%).

In Table 1, the number of live births and the overall and cause-specific mortality rates are presented by maternal age, parity, smoking habits, and length of education. Regarding maternal age, a U-shaped pattern can be seen, with the highest rates for the youngest and the oldest mothers. The exception to this pattern are death rates due to congenital conditions, which increase with increasing age, and to sudden infant death syndrome, which decrease. When parity was high, mortality rates in general markedly increased. Maternal smoking greatly increased risks for sudden infant death syndrome, for which a dose-response relationship was observed. To some extent, this was also found among deaths caused by immaturity-related conditions.

The influence of the mother's education on infant mortality rates followed a U-shaped pattern for total infant mortality and for deaths caused by congenital and asphyxia-related conditions. Sudden infant death syndrome mortality decreased with length of education. Except in cases of deaths caused by infections, mortality rates were higher than average when information on education was missing. It is likely that women for whom such information was missing have less education.

Results from the multiple logistic regression analyses are presented in Table 2. For most causes of death, the fit of the model was better when adjustment was made for smoking habits as well as for age and parity. For asphyxia-related conditions, the model was significant only when smoking habits were included. The crude odds ratio for mother's education ranged from 1.0 to 2.9 for the different causes of death.

The differences between crude and adjusted odds ratios were minor except for deaths from sudden infant death syndrome. The crude odds ratio for the group with the least education was 2.6. When adjusted for age and parity, the odds ratio changed to 1.6, and with further adjustment for smoking habits, it was reduced to 1.3. A similar pattern was also found among women with 10 to 11 years of education.

This led to further analysis of the effects of mother's education and smoking habits on sudden infant death syndrome (Table 3). If the mother smoked between 1 and 9 cigarettes per day, the risk for sudden infant death syndrome was 1.5 times higher than it was among nonsmokers, with adjustment for maternal age and parity. If the mother smoked 10 cigarettes or more per day, the risk was 2.4 times higher. Adjusting also for length of education did not give better estimates.

Discussion

In Sweden, the gap between low and high social class has decreased in many respects. There are no social differences regarding availability of and access to health care for the mother and child. The prenatal and child health care system is available for everyone, and specialized hospitals are available at no or low cost for those who need special care.[16] Housing conditions are generally good, income differences have become smaller, and there is hardly any real poverty.

There are differences, however, in length of education in Sweden. It is probably easier for a person with a long education to understand information on prevention and risk factors and to know when to turn to the health care system for help. Using education as a social indicator is also intuitively interpretable and useful for international comparisons. In studies from different countries, education has been found to discriminate between social groups[6,17] and to be useful as socioeconomic measure[18] partly because of its simplicity.[19]

When analyzing Swedish infant mortality by groups of causes of death, an obvious social pattern—as measured by length of education—was found for sudden infant death syndrome only. The crude odds ratios for sudden infant death syndrome among infants to mothers with the least education were significantly increased. This result is in accordance with other studies, in which analyses of sudden infant death syndrome without adjustments for other characteristics showed that the risk was increased if education was short[6,20] or if the family was poor.[7] Maternal age, number of births, and smoking habits are factors that vary between social groups and affect mortality. As these variables were successively included in the analyses, the elevated risk for sudden infant death syndrome among infants to women with less education decreased and finally disappeared. In the results obtained,

Smoking Habits	Mortality per 1000	Odds Ratios (95% CI)		
		Crude	Adjusted for Age and Parity	Adjusted for Age, Parity, and Education
Nonsmoker (reference)	0.7	1.0	1.0	1.0
1–9 cigarettes/day	1.2	1.6 (1.2, 2.2)	1.5 (1.1, 2.0)	1.5 (1.1, 2.0)
≥ 10 cigarettes/day	1.9	2.6 (2.0, 3.5)	2.4 (1.8, 3.1)	2.2 (1.6, 3.0)
P value of the model		0.0001	0.0001	0.0001

TABLE 3—Mortality Rates and Odds Ratios for Sudden Infant Death Syndrome,[a] by Smoking Habits

[a]Live single births in Sweden, 1983 to 1986, among Nordic citizens.

significant crude odds ratios were the consequence of an overrepresentation of young mothers, multiparous mothers, and smoking mothers among women with less education.

The results show the importance of including smoking habits in this type of study. Most likely, some of the social differences obtained in other studies were effects of different smoking habits in different social groups, no matter how the social variable was measured.

To detect differences in risks associated with maternal characteristics for certain causes of infant death, the causes should be grouped to ensure homogeneity within them and heterogeneity between them. Whether a cause of death was reported as due to immaturity- or asphyxia-related conditions appears to be determined by chance in some instances. There might also be some misclassifications. In this study, in 55 deaths (13%) classified as immaturity related, the birthweight was 2500 g or more.

It is also important that the groups are not too small. This study included practically all live births in Sweden during 4 years. Still, the number of deaths in some groups was relatively low, and the resultant mortality rates were so low that they were difficult to interpret. Thus the general impact of these deaths cannot be very strong, and these groups may not be very important from a public health perspective.

There is no generally adopted way to group causes of infant death. Main groups of three-digit ICD-codes have been analyzed.[3,21] However, the ICD is based more on organs affected than on the etiology involved. To obtain groups that are more homogeneous with regard to etiology and/or aspects of care and prevention, the groupings have been modified by experts.[6,7,9,17,22] In this study, a grouping

originating from international collaborative effort was used.[11] In other studies deaths have been classified into one major group of preventable causes and another of nonpreventable causes.[2,6,23] However, the definitions of these groups differ. There seemed to be a general agreement that congenital conditions or malformations are nonpreventable, whereas sudden infant death syndrome was sometimes seen as preventable[2,23] and sometimes not.[6] In the present study, the risk for sudden infant death syndrome was significantly influenced by the mother's smoking, which must be assessed as a potentially preventable risk factor.

During this period in Sweden, social class, as measured by length of mother's education, played a minor role as a risk factor for all causes of infant death. The increased risk for sudden infant death syndrome among infants to mothers with short education was substantially related to differences in maternal age, parity, and smoking habits. It seems reasonable to assume that the relatively minor importance of maternal education on infant survival was a consequence of a generally high standard of living; of high medical, technical, and economic developments; and of the nationwide, free prenatal and child health care system. □

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APPENDIX 1—Causes of Death Grouped by International Classification of Diseases Codes

Causes grouped by ICD-8 codes	
Congenital conditions	250, 270–275, 282–284, 286–288, 330–333, 390–398, 424–426, 437, 538, 550–553, 560, 571, 573, 599, 738, 740–748.2, 748.4–759, E930, and E932
Sudden infant death syndrome	795
Asphyxia-related conditions	343, 764–768, 769.9, 770, 771, 776.0, 776.3, 776.4, and 776.9
Immaturity-related conditions	9.2 if neonatal, 423, 561, 748.3, 760–763, 769.0–769.5, 772–774, 776.1, 776.2, 777, 778, 782, and 783
Infections	1–8, 10–136, 320–324, 381, 382, 420–422, 460–483, 485–491, 510, 511, 513, 540, 567, 570, 590, 682, 686, and 720
Remaining conditions	Remaining applicable codes
Causes grouped by ICD-9 codes	
Congenital conditions	270–275, 277–279, 282, 284, 286–288, 330, 335, 359, 394–411, 414–417, 424–426, 550–553, 560, 571, 572, 740–759, and 777.1
Sudden infant death syndrome	798
Asphyxia-related conditions	343, 761.6, 761.7, 762.0–762.2, 762.4–762.6, 763, 766–768, 770.1, 772.2, 779.0, and 779.2
Immaturity-related conditions	761.3–761.5, 761.8, 761.9, 762.7, 764, 765, 769, 770.2–770.9, 772.1, 774, 777.5, 777.6, 778.2, 779.6, and 779.8
Infections	001–139, 254.1, 320–326, 382, 420–422, 460–466, 475–477, 480–491, 510, 511, 513, 540, 541, 566, 567, 570, 572.0, 590, 591, 770.0, 771, and 790
Remaining conditions	Remaining applicable codes

Note. In our study there were 12 cases where the cause of death is missing. These were grouped together with remaining conditions.